

CHAPTER 5
INSTRUMENTATION AND CONTROLS

1. SENSING DEVICES.

a. General. The following sensor descriptions include the majority of instrument types used to interface the UMCS to utility systems for monitoring of system conditions and operation. Transmitters providing a DC signal proportional to the required analog measurement will be included as a part of each instrument to provide a linear conditioned signal for input to field equipment panels. The designer will refer to TM 5-815-3, HVAC Control Systems, for additional information regarding the application of sensing devices to HVAC systems.

b. Temperature instruments.

(1) Temperature instruments include various configurations of platinum resistance temperature detectors (RTDs) and require proper housing for temperature measurement in rooms, ducts, piping, and outside air (OA). The selection of a platinum RTD for the specific application depends upon the required range and accuracy. Thermistors will not be used in UMCS applications. Thermocouples will not be used in UMCS applications except in the specific case when the measured temperature might exceed the maximum recommended temperature for platinum RTDs (about 1,800 degrees F) or when the thermocouples are provided by the manufacturer of rotating machinery for bearing or coil temperature measurement. Conditioning circuitry is required, and will be integral to the sensor.

(2) Continuous averaging RTDs have long, flexible sensing elements. They are installed in a serpentine fashion in the cross-section of a duct to reduce measurement errors due to air stratification. The continuous averaging RTD transmitter output signal represents the average temperature along the sensing element.

(3) Temperature switches are bimetallic or filled elements affected by temperature changes that cause contacts to open (or close) at a selected temperature setting. Temperature switches must be adjustable over the operating temperature range.

(4) Temperature instruments on pipes or boiler stacks will be installed in thermowells. The thermowell material will be selected based on the piping material and properties of the fluid in which the thermowell is immersed.

(5) Outside air temperature instruments will be installed in instrument shelters to prevent the sun from directly striking the sensors, and will be located and mounted to minimize direct solar radiation and conductive heat transfer to the building.

c. Relative humidity instruments are used to measure percent relative humidity in spaces, ducts, and OA. Where OA measurements are required, shielding will be provided to neutralize the effects of solar heating and rain.

d. Pressure instruments.

(1) Pressure transducers are pressure measurement devices which use the deformation of an elastic membrane as the primary measuring device. The various pressure transducers include bellows, diaphragm, bourdon tube, and strain gage types. Pressure transducers are subdivided into a number of categories including those for measuring gauge pressure, absolute pressure, and differential pressure.

(2) Pressure switches are operated by an input pressure to open or close contacts at a selected pressure setting. Pressure switches may be gauge, absolute, or differential type with adjustable settings, and may be manual or automatic reset.

e. Flow instruments.

(1) Flow of liquids and gases is directly or indirectly measured in the flow path. A direct metering device measures fluid flow by measuring volume or weight for a given period of time. An indirect metering device uses an intermediate parameter, such as pressure drop across a constricted flow area, to measure flow.

(2) Concentric orifice plates will be used for measuring steady flow of clean liquids, vapor, or gas in the normal turbulent flow region with a Reynolds number of 2000 or greater.

(3) Eccentric orifice plates are used to measure fluids which carry a small amount of non-abrasive solids, since the solids will flow through the bottom of the orifice rather than accumulate behind it. They are also useful for measuring the flow of vapors or gases which carry small amounts of liquid. Eccentric plates will also be used to measure the flow of liquids carrying small amounts of gas, in which case the orifice opening must be located at the top of the pipe.

(4) Flow nozzles will be used where the Reynolds number is in excess of 50,000. Flow nozzles will handle approximately 60 percent more flow with the same pressure drop, compared to an orifice plate. At higher Reynolds numbers, the amount of straight pipe required prior to the flow nozzle is reduced.

(5) Venturi tubes, like flow nozzles, will handle approximately 60 percent more flow than an orifice plate, but with the same pressure drop as the orifice plate. For equal flows, the pressure drop of a venturi tube will be only 10 to 20 percent of the pressure drop of an orifice plate. The venturi tube is capable of measuring any fluid flow which an orifice plate or flow nozzle can measure. Venturi tubes will be used for gas flow measurement when suspended particles are in the stream.

(6) Annular pitot tubes are a variation of the pitot tube. Pitot tubes have a single sensing point and have poor accuracy, particularly at low velocities. The annular pitot tube senses dynamic pressure at multiple ports distributed along the sensing tube to provide a single output of the average flow. Static pressure is measured by a port which faces downstream at the centerline of the pipe. The sensor requires approximately five pipe diameters of straight pipe upstream of the device. A major advantage of this sensor is the ability to install an annular pitot tube into an existing line under pressure with "hot tap" methods.

(7) Turbine flow meters use the moving fluid to turn a turbine rotor. Turbine flow meters supply flow quantity information via a precisely known number of pulses for a given volume of fluid displaced. The relationship is linear for a given flow rate and viscosity. The turbine flow meter is designed on flanged ends to be mounted in-line. Recently, reduced size turbine meters have been developed for mounting into existing piping by hot-tap methods, allowing the units to be removed and reinserted without system shutdown.

(8) Vortex shedding flowmeters use a non-streamlined obstruction inserted in the pipe centerline to create eddies or vortices which grow. The detachment of the vortex from the obstruction is termed shedding. A sensor located downstream of the obstruction measures the frequency of shedding, which is proportional to the flow velocity, the output being linear with flow.

(9) Air flow measurement stations may be of the pitot-tube or electronic type. For applications where the minimum required flow measurement corresponds to an air velocity of less than 1,000 feet per minute, the electronic type air flow measurement station will be used. Both types have sensing elements distributed throughout the cross-section of the duct.

(10) Gas utility flow meters are diaphragm or bellows type (gas positive displacement meters) for flows up to 2,500 standard cubic feet per hour (SCFH) and axial-flow turbine type for flows above 2,500 SCFH. These meters, which are designed specifically for natural gas supply metering, have electrical impulse dry contact outputs for input to UMCS.

(11) Flow switches are operated by input flow to open or close contacts at a selected flow setting. Flow switches must be adjustable over the operating flow range.

f. Level instruments.

(1) For vented tanks with accessible bottom taps, a pressure transducer connected to a bottom tap will be used for level measurement. The pressure measurement is converted to a level measurement by the UMCS based on the density of the liquid in the tank. In certain cases, where temperature is expected to vary widely and the density of the liquid varies significantly with temperature, a temperature measurement is required for compensation of the engineering units conversion. If the tank is pressurized and both bottom and top taps are accessible, level will be measured using a differential pressure transducer and engineering units conversion based on density.

(2) For sumps or tanks without accessible taps, capacitive liquid level sensors will be used. For measurement of non-conductive liquids or where sloshing of the liquid is expected, the liquid level sensor will be installed in a perforated steel stilling well.

(3) Bubbler type liquid level sensors will be used for level measurement of fuel oil or extremely caustic or corrosive liquids. Compatibility of the wetted tubing with the liquid will be assured by the designer.

(4) Liquid level switches are combinations of displacer floats suspended from a stainless steel cable attached to the switch housing. Changes in liquid level near the elevation of the displacers results in varying downward force on the stainless steel cable, which actuates the switch mechanism. Liquid level switches will be used where the UMCS is required to actuate specific alarms or controls at defined liquid levels, but continuous monitoring of liquid level is not required.

(5) Float switches will be utilized for sewage lift station pits or similar applications with corrosive liquids and floating solids. Float switches are mercury-free tilt switches rigidly mounted in bouyant polypropylene (or other corrosion-resistant material) floats. The floats are secured at the elevation where switch actuation is desired, and the tilt switches actuate when the liquid level tilts the float.

g. Electrical power instruments.

(1) Electrical energy consumption measurements require the use of voltage and current transformers whose proportional outputs are connected to a dedicated watt-hour meter or transducer, or to a field equipment panel where the watt-hour consumption calculations are performed. Where dedicated watt-hour meters are used, a dry contact pulse output is required from the meter for input to the field equipment panel. Where watt-hour transducers are used, an analog output is required for input to the field equipment panel.

(2) Electrical peak demand is calculated from the output of potential (voltage) and current transformers used for the electrical energy measurements or by the use of dedicated electrical peak demand transducers with an analog output to a field equipment panel.

(3) Voltage and current measurements for ranges which do not match field equipment panel input requirements will require the application of voltage and current transformers.

(4) Some electrical utility management applications require measurement of reactive power (volt-amperes reactive or VAR) in addition to real power. VAR transducers will be used for measurements of reactive power in three phase electrical power systems.

(5) Power factor transducers provide an analog output proportional to the cosine of the phase angle difference between the voltage and current of three phase electrical power systems.

h. Position sensors.

(1) Position sensors measure the position of devices such as valves and dampers which move from one position to another. Typical position instruments include end (limit) switches and potentiometers.

(2) End (limit) switches provide a contact closure at or near the limit of the moving object's travel.

(3) Potentiometers are resistors with a continuously adjustable sliding contact. Depending on the application, these devices may be either rotary or linear. They will indicate position on a percent open basis.

i. Key-operated switches including hand-off-automatic (HOA), and off-automatic, must be keyed alike. Key-operated switches will be provided with status feedback auxiliary contacts connected to a field equipment panel for UMCS alarming of abnormal switch positions, such as an HOA switch not in the automatic position.

j. Additional sensing devices used in UMCS may include water analysis sensors for water system characteristics such as pH, conductivity, turbidity and total dissolved solids; flue gas analysis sensors such as carbon monoxide, oxygen, and nitrous oxide monitors; ambient environmental sensors such as carbon monoxide detectors, chlorine gas detectors, oxygen depletion monitors and refrigerant leakage monitors; and specialty system sensing devices such as compressed air dewpoint sensors.

2. CONTROL DEVICES.

a. It is necessary to add output devices of various types to allow the UMCS to control utility system operations. The following control device descriptions include the majority of controller interfaces required between the UMCS and utility systems. The designer will refer to TM 5-815-3, HVAC Control Systems, for additional information regarding the application of control devices, valves and dampers to HVAC systems. Output devices include the following types:

b. Electrical relays are operated in a maintained, momentary, magnetically held, or latching configuration by an output from a DO in the smart field panel to operate equipment directly or through contactors. The most common types of relays for UMCS applications are time delay relays, latching relays, and solid state relays.

(1) Time delay relays operate so that there is a time lag between energizing and deenergizing a circuit. These relays may be used when there is a need to delay start-up, recycling, and/or shutdown of equipment and during failure mode application.

(2) Latching relays physically "lock" themselves in the energized or deenergized position until they are manually or electrically reset.

(3) Contactors are single coil, electrically operated, magnetically held devices that are used by relays to operate equipment.

(4) Solid state relays are semiconductor based switches with sufficient rating to replace electromagnetic relays.

c. Electric solenoid operated pneumatic (EP) relays are operated in an on-off manner electrically by a digital output. EP relays are placed in a pneumatic local loop control circuit to apply air pressure to a device, exhaust air pressure from a device, or transfer control from one device to another. Control air is obtained from the existing compressed instrument air system.

d. Controllers continuously measure changes in controlled variables and automatically send appropriate signals to adjust equipment or devices to correct any deviation from the desired setpoint.

(1) Single input Control Point Adjustment (CPA) controllers are used when reset control is required. The setpoint of the controller must be adjustable over a range of plus or minus ten percent of the primary sensor span.

(2) Dual input controllers can be used instead of single input CPA controllers when the adjustable control range needs to exceed more than plus or minus 10 percent of the primary sensor span.

(3) Some electric and electronic controllers have CPA or remote setpoint inputs, which may require a 4 to 20 mA signal or a varying resistance (rheostat) input to adjust the control loop setpoint. An example is a centrifugal chiller capacity controller which permits gradual chiller demand limiting by the UMCS.

e. Current to pneumatic (I/P) transducers are electrically operated by an AO in the smart field panel. The AO signal is converted into a pneumatic output signal compatible with the local control loop or actuator. These proportional signals position valves, dampers, and reset local loop control setpoints.

3. MICROPROCESSOR-BASED CONTROLLERS.

a. Many HVAC, utility and process systems utilize microprocessor-based controllers. One example is the single-loop digital controller utilized in standard control panels for HVAC control systems. Standard control panels include interfaces for connection to UMCS. Another example is an application-specific unitary controller provided as a packaged equipment control system by an equipment or system supplier.

b. Some microprocessor-based controllers may be interfaced with a UMCS smart field panel with a controller communication port which utilizes a standardized communication interface such as EIA 485. In this case, up to 32 microprocessor-based controllers may be interfaced on a single communication circuit to a smart field panel. The designer will investigate existing microprocessor based controllers to determine if they are equipped with the controller communication port.

c. If the existing microprocessor-based controllers do not include controller communication ports, the designer will consider two options for interface of the controllers with the UMCS. The first option is replacement of the existing microprocessor-based controllers with units equipped with the proper controller communication ports. The second option is to provide CPA interface to the microprocessor-based controllers through 4 to 20 mA analog outputs if the controllers are equipped to accept a remote setpoint signal.